

PLACEMENT	TIME	LENGTH (APPROX)
6/27 RADIO		
WCBS-AM	12:00 AM	5 MINUTES
WBAL-AM	8:00 AM	2 MINUTES
WOR-AM	5:10 AM	15 SECONDS
	7:00 AM	15 SECONDS
	10:00 AM	15 SECONDS

\* -- DENOTES TAPE ENCLOSED

@ -- DENOTES TRANSCRIPT ENCLOSED

1 -- VOICE OF AMERICA IS BROADCAST IN EVERY NATION OF THE WORLD, AND HAS 120,000,000 WEEKLY LISTENERS.

2 -- PAUL HARVEY NEWS SERVICES 1350 STATIONS (U.S.), 400 (OVERSEAS); 22 MILLION WEEKLY LISTENERS.

3 -- NATIONAL PUBLIC RADIO'S "ALL THINGS CONSIDERED" SERVICES 360 STATIONS IN THE U.S.

4 -- WALL STREET JOURNAL RADIO NETWORK SERVICES 140 STATIONS IN THE U.S.

5 -- AP RADIO NETWORK SERVICES 900 STATIONS IN THE U.S.

6 -- ABC TALK RADIO NETWORK SERVICES 110 STATIONS IN THE U.S.

FOR BURSON MARSTELLER

PROGRAM NEWS RADIO 88 STATION WCBS-AM

DATE JUNE 25, 1990 12:00 Mid CITY NEW YORK

BROADCAST EXCERPT

NEWSCASTER: The Motorola company says it plans a new telephone network to fill in the gaps in the world's telecommunications system. It plans to begin orbiting tiny satellites that will link cellular telephone world wide, and which the company says will make calling from London to the African desert as easy as calling from across the street. The new system is expected to become operational in 5 years.

FOR BURSON MARSTELLER

PROGRAM BUSINESS NEWS

STATION WCBS/R

DATE JUNE 26, 1990

6:25 A.M.

CITY NEW YORK

BROADCAST EXCERPT

BRIDGET QUINN: And time to update the business news with Dean Sheppard of Money Magazine.

DEAN SHEPPARD: And Bridget, two major unveilings in the world of technology coming up later today. IBM will make its re-entry into the home computer market with its new PS-1. A PC that in its basic form will sell for less than 1,000 dollars. While this new machine is a far cry from the PC Junior which was a marketing disaster for IBM, there's already some grouching about how difficult it is to expand the PS-1's computing power. And from Motorola plans for a two billion dollar world-wide cellular telephone system, using dozens of low orbit satellites. And speaking of Motorola, the company may be close to burying the hatchet with Japan's Hitachi in their on-going patent dispute over computer chips. The two companies say they have reached tentative agreement on a plan to settle their 18-month old dispute.

000000 RTI

INTRO: THE MOTOROLA COMPANY, THE AMERICAN ELECTRONICS FIRM, ANNOUNCED TODAY (TUESDAY) FOR A WORLDWIDE COMMUNICATIONS SYSTEM THAT WILL ALLOW PEOPLE ANYWHERE ON EARTH TO CALL EACH OTHER USING PORTABLE WIRELESS TELEPHONES. CORRESPONDENT LARRY FREUND REPORTS ON THE ANNOUNCEMENT IN NEW YORK.

TEXT: MOTOROLA OFFICIALS HELD NEWS CONFERENCES THROUGHOUT THE WORLD TO UNVEIL WHAT ONE COMPANY EXECUTIVE CALLED MOTOROLA'S MOVE INTO THE SPACE FRONTIER. THE FIRM HOPES TO INSTALL A COMMUNICATIONS SYSTEM -- CALLED "IRIDIUM" -- USING 77 SPACE SATELLITES IN LOW-EARTH ORBIT AND PORTABLE CELLULAR TELEPHONES. MOTOROLA'S VICE CHAIRMAN JOHN MITCHELL SAID FULL SERVICE WILL BEGIN AS EARLY AS 1996.

///MITCHELL ACTUALITY///

IRIDIUM WILL ALLOW HUMANS ON EARTH -- WHETHER ON LAND, SEA OR IN THE AIR -- TO COMMUNICATE WITH ANYONE ELSE, WITH NO BOUNDARIES, NO RESTRICTIONS, IMMEDIATELY. USING IRIDIUM EQUIPMENT, YOU WILL BE ABLE TO REACH PEOPLE BY

///END ACTUALITY///

THE MOTOROLA COMPANY SAYS THE COST OF THE IRIDIUM SYSTEM WOULD BE MORE THAN TWO BILLION DOLLARS. THREE ORGANIZATIONS -- THE LONDON-BASED INTERNATIONAL MARITIME SATELLITE ORGANIZATION, THE AMERICAN MOBILE SATELLITE CORPORATION AND TELESAT MOBILE, INCORPORATED, OF CANADA -- HAVE SIGNED AGREEMENTS WITH MOTOROLA TO EXAMINE THE SYSTEM. THE ELECTRONICS FIRM SAYS IT IS HOLDING DISCUSSIONS WITH OTHER POTENTIAL PARTNERS IN LONDON, AUSTRALIA, HONG KONG AND JAPAN. ONE COMMUNICATIONS EXECUTIVE OBSERVED THAT THE FINANCIAL, TECHNICAL AND POLITICAL BARRIERS TO THE SYSTEM ARE CONSIDERABLE BUT, HE ADDED, THE REWARDS ARE ALSO CONSIDERABLE.

///REST OPT///

MOTOROLA'S GENERAL MANAGER FOR SATELLITE COMMUNICATIONS, DURRELL HILLIS, DESCRIBED THE 77 SPACE SATELLITES THAT ARE CENTRAL TO THE PROPOSED COMMUNICATIONS SYSTEM.

///HILLIS ACTUALITY///

EACH WILL BE ROUGHLY ONE METER IN DIAMETER AND TWO METERS TALL IN ITS LAUNCH CONFIGURATION AND WILL WEIGH ROUGHLY 315 KILOGRAMS. THEY WILL BE DEPLOYED IN SEVEN CIRCULAR POLAR ORBITS WITH 11 SATELLITES SPACED EVENLY, TRAVELING IN THE SAME DIRECTION IN EACH ORBITAL PLANE. THEY ARE CONSIDERED TO BE "SMART" BECAUSE EACH SATELLITE WILL SWITCH AND ROUTE CALLS IN SPACE.

///END ACTUALITY///

THE GLOBAL TELEPHONE NETWORK ENVISAGED BY THE MOTOROLA COMPANY WOULD NOT COMPETE WITH EXISTING CELLULAR TELEPHONE SYSTEMS THAT USE RADIO TOWERS IN CITIES THROUGHOUT THE WORLD. (SIGNED)

FOR

BURSON MARSTELLER

PROGRAM

PAUL HARVEY NEWS

STATION

WOR RADIO

DATE

JUNE 26, 1990

8:30 A.M.

CITY

NEW YORK

**BROADCAST EXCERPT**

PAUL HARVEY: The portable telephone in your pocket is a miracle of convenience, but limited to use in your hometown.

Motorola is now building a new cellular telephone system using satellites, enabling you with your twenty-five ounce pocket phone to make and receive calls anywhere in the world. "The Eridiam System" to be fully operative within five years.

Now page 2.

FOR BURSON MARSTELLER

PROGRAM WINS NEWS

STATION WINS-AM

DATE JUNE 26, 1990

12:27 AM

CITY NEW YORK

BROADCAST EXCERPT

LARRY KOSKI: Motorola plans an announcement today of plans to develop a global cellular telephone system. The system would require the launching of 77 small satellites to carry signals. Motorola starts at 84 1/8, down 1 7/8.

FOR           BURSON MARSTELLER

PROGRAM       WALL STREET JOURNAL REPORT           STATION       WGCH/R

DATE           JUNE 26, 1990                       7:50 A.M.           CITY           GREENWICH, CT

BROADCAST EXCERPT

SAL GIANGRASSO: Motorola signs a worldwide satellite cellular telephone system that would connect users just about anywhere in the world as early as 1996. But Motorola needs money, regulatory clearance and customers.

FOR BURSON MARSTELLER

PROGRAM AP RADIO NETWORK

STATION WFAS/R

DATE JUNE 26, 1990

9:00 A.M.

CITY WHITE PLAINS, NY

BROADCAST EXCERPT

MIKE HAMRICK: The day may not be far away when you never may be able to be out of touch. Motorola has announced plans to build a satellite-based cellular phone system that it says will enable you to make a call from anywhere on the planet by the end of the decade. Motorola's system will use 77 satellites. It is projected that the cost will be around 3500 dollars for a phone.

**ATTENDED:**

**Print**

Mario Suriani	ASSOCIATED PRESS (PHOTO)
Bart Ziegler	ASSOCIATED PRESS
Jim Asker	AVIATION WEEK AND SPACE TECHNOLOGY
Leslie Cauley	BALTIMORE SUN
Evan Schwartz	BUSINESS WEEK
Naqi Jaffery	CABLE INVESTOR NEWSLETTER
Paul Gluckman	COMMUNICATIONS DAILY
Ed Atman	COMMUNICATIONS WEEK
Terry Sweeney	COMMUNICATIONS WEEK
David Rocks	COMMUNICATIONS WEEK INTERNATIONAL
Neeraj Khemlani	COMMUNICATIONS WEEK INTERNATIONAL
Jim Duffy	COMPUTER SYSTEMS NEWS
John Mulqueen	DATA COMMUNICATIONS
Mike Markowitz	EDN
Rick Doherty	ELECTRONIC ENGINEERING TIMES
Benedict Fehr	FRANKFURTER ALLGEMEINE
Diane Medina	INFORMATION WEEK
Colleen Connoly	MARINE ENGINEERING LOG MAGAZINE
Robert Price	NATIONAL LAW JOURNAL

Karen Neil	NATIONAL LAW JOURNAL
Karen Frusher	NEW YORK LAW JOURNAL
Keith Bradsher	NEW YORK TIMES
Dawn Stover	POPULAR SCIENCE
Frank Barbetta	PROBE RESEARCH
Jo An Kelly	REUTERS
Robert Blumel	SATELLITE COMMUNICATIONS
Gary Stix	SCIENTIFIC AMERICAN
Melinda Gipson	SPACE BUSINESS NEWS
Dan Marcus	SPACE NEWS
Bob O'Brien	TELECOMMUNICATIONS
Ed Liebowitz	TELECONNECT
Ken Ficara	TELESCOPE NETWORKS
Isabelle Clary	UNITED PRESS INTERNATIONAL

Broadcast

Charles Zachariah	ABC-TV NEWS
Juju Chang	ABC-TV NEWS
Steve Young	CABLE NEWS NETWORK
Fred Fishkin	CBS - RADIO
Grog Coppa	CBS-TV NEWS
Alec Sirken	CNBC-TV
Michael Strauss	FINANCIAL NEWS NETWORK
Kathleen Zaff	FINANCIAL NEWS NETWORK
Phil Buckman	NBC-TV NEWS
Lawrence Freund	VOICE OF AMERICA
Len Trugman	WABC-TV NEWS
Vielka Todd	WALL STREET JOURNAL REPORT



**Attachment B**

**PAPER ENTITLED**  
**LOW-EARTH ORBIT GLOBAL**  
**CELLULAR COMMUNICATIONS NETWORK**  
**DR. RAYMOND J. LEOPOLD**  
**(AUGUST 23, 1990)**

## LOW-EARTH ORBIT GLOBAL CELLULAR COMMUNICATIONS NETWORK

Dr. Raymond J. Leopold  
Motorola Satellite Communications  
2501 South Price Road  
Chandler, Arizona 85248  
United States of America

### Abstract

The technical parameters which led to Motorola's newly announced Iridium™ system are discussed. The Iridium™ system is a worldwide, digital, satellite-based, cellular, personal communications system primarily intended to provide commercial, low-density, mobile service via portable, mobile, or transportable user units, employing low-profile antennas, to millions of users throughout the world. Calls can be made and received anywhere in the world with a personal, portable unit. Seventy-seven small (320 Kg), smart satellites are internetted to form the network's backbone. Small, battery-powered, cellular-telephone-like user units communicate directly to the satellites. Gateways (earth stations) interface from the satellites to the individual Postal, Telephone and Telegraph Authorities (PTTs). The system is intended to complement the terrestrial cellular telephone systems installed, or being installed, in densely populated areas by providing a similar service everywhere else in the world. The Iridium™ system is much more than the technology that allows it to be built -- Iridium™ is a vision, a realizable vision, for a worldwide portable, personal communications system -- a vision whose greatest realization, like the telephone of a century ago, is beyond today's imagination.

### Introduction

The Iridium™ system was named by a cellular telephone system engineer, Jim Williams, who works in a Motorola facility in a suburb of Chicago -- the 77-satellite constellation reminded him of the electrons encircling Bohr's atom, so Mr. Williams looked to see what element has 77 electrons. The instant he suggested the name, Iridium™, a twinkle flashed in the eyes of the rest of the Iridium™ team -- they knew their system had been named. It was some 15 months later, just prior to the public announcement of the Iridium™ system that the team learned that the high concentration of iridium in a large meteor which struck the earth is "credited" with providing the final blow to the earth's dinosaur population -- the team could only wonder what conjecture would follow -- it was too late, the name was not going to be changed, the announcement was imminent.

The Iridium™ system is truly an amalgamation of technologies that were creatively interwoven by a small team of engineers with dissimilar backgrounds inside a company with diverse areas of expertise. The key technologies include wireless communications in two realms: space communications systems and cellular telephone systems. Important supporting technologies include small satellites, phased-array antenna systems, functionally-dense radiation-tolerant semiconductors, advanced baseband processing architectures, and distributed network architectures.

The global international economic industrial process providing the momentum for the Iridium™ system is man's apparently unquenchable desire for mobile communications. The demand for terrestrial cellular telephone service has far outpaced the marketers' projections, and the usage patterns are tied quite closely to local demographic considerations. Currently, the highest demands for service are during the "rush hour" commuter periods in Los Angeles, where the car telephone both extends the business day and eases the drivers' tension. The number of cellular telephones now exceed 7 million--the number anticipated in 1983 to be achieved by the year 2000. More recent projections now are as high as 100 million, worldwide, by 2000. The Iridium™ system does not replace or substitute for

cellular telephone service, but rather extends the radio-telephone coverage area to the entire world. Iridium™, by its very nature, is a lower-density, higher-priced service than cellular. For a given amount of spectrum, a common modulation/multiplexing technique, and reuse pattern, the system capacity is driven by the number of cells that are created. Cellular telephone systems employ cells that have diameters as small as 1 mile, whereas Iridium™ cells are about 400 miles wide, and, Iridium™ per minute cost for service is estimated to be 3 to 10 times that of cellular. So where is the advantage?

Where an area is covered with a terrestrial-based cellular system, the Iridium™ system is a backup or emergency service. In areas of the world where no mobile service is readily available, the Iridium™ system is the mobile system. In areas of the world where mobile service is only provided with geostationary satellites, the Iridium™ system provides more channels, shorter delays, and worldwide networking. And, in areas of the world where there is no telephone service, the Iridium™ system can provide telephone service.

Iridium™ customers will be widespread and varied. An international business person with a portable unit in his coat pocket can have easy access to the home office, and the head of a large multinational corporation can quickly call any of his general managers, whether they are at home or traveling on the earth's surface or in the air, anywhere in the world. The mountain climber, skier, or recreational sailor can continue to communicate with his brokerage business. Third world countries without a telephone infrastructure can have subsidized, solar-powered, centrally-located telephone "booths" in every village. Land and sea mining operations can have continuous worldwide service. And, areas experiencing natural disasters can maintain a reliable communications linkage to the rest of the world.

Some of the primary technical parameters of the Iridium™ system are described here, but quite obviously, the foremost challenges are not in the technology -- the regulatory and licensing aspects of a truly worldwide, portable radiotelephone service are clearly the dominant issue areas. The technology is at hand, the authority to provide this service to all mankind is to be debated.

## Scope

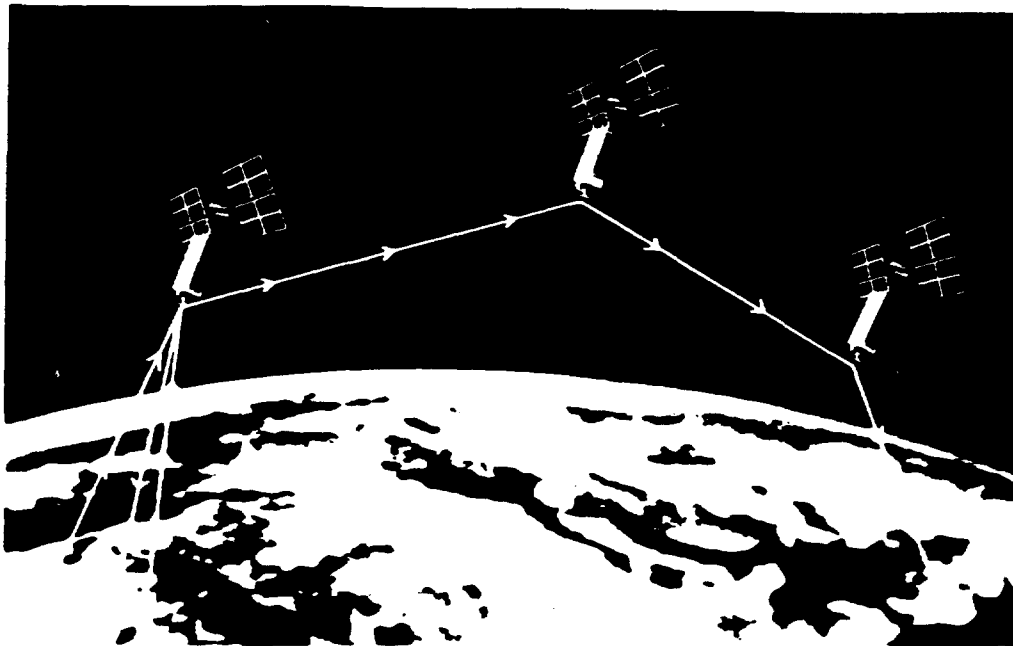
Prior to describing the Iridium™ system further, it is useful to state what the Iridium™ system is not. It is not a substitute for existing telephone or cellular telephone systems, which by their nature have much more capacity and lower rates. It is not a system that guarantees building penetration from a portable unit, yet its low-data-rate "ringer" will function at a much higher link margin. It is not a service which will categorically bypass local, national, or international excise taxes.

The Iridium™ system does provide direct line-of-sight communications to and from portable subscriber units on or above the earth's surface. The Iridium™ system is a digital communications system that operates in a cellular communications architecture. The constellation of satellites covers the earth with cells that allow channels to be reused many times. The individual cells are turned on/off as needed to cover the world.

The Iridium™ Mobile Satellite Communications System is a system that is in development, and though a complete, integrated baseline design exists, tradeoff analyses continue, and the final design for the satellites will not be frozen until early 1992. The system is to become operational by the end of 1996.

## The Constellation

The constellation was chosen from among a family of constellations described by Adams and Rider (1), which provide full-earth coverage with a minimum number of satellites. The constellation employs optimally-phased polar orbits in which the satellites in the odd-numbered planes are in phase with one another but halfway out of phase with those in the even-numbered planes. The satellites



When placing a call on the Motorola Iridium system, the signal is transmitted from the caller's portable cellular phone directly to the nearest overhead satellite, which in turn sends the signal to an earth "gateway" station that verifies the caller as an authorized user. The call is then routed through the constellation of satellites to its destination anywhere on earth.



The heart of Motorola's Iridium system is a "constellation" of 77 satellites arranged in seven polar orbital planes. Each plane contains 11 satellites.

essentially travel, in co-rotating planes, up one side of the earth, cross over at the pole and come down the other side of the earth. (The earth, of course, continues to rotate beneath them.) There is an area between the first and last planes where the satellites are essentially counter-rotating. Since the counter-rotating "seam" in the constellation does not cover the earth's surface with the efficiency of the optimally-phased co-rotating planes, Adams and Rider separate the first and last planes less than the co-rotating planes. Alternative constellations (e.g., those at other inclinations) would either require more satellites, higher altitudes, or a combination of both.

As an aside, nevertheless an important aside, it should be noted that for a cellular system that employs fixed geometry beams (keeping the satellites' antennas less complex than electronically scanned beams), it is important to keep each of the cells projected on the earth as equal in area as possible. This allows the system capacity to be set at a nominal level, and not limited to the largest (least dense) cell. Therefore, the circular orbits are very desirable.

The Iridium™ system engineers chose a constellation, from among the family of constellations defined by Adams and Rider, with the configuration of seven planes, eleven satellites per plane for the reasons described below. This constellation employs co-rotating planes separated by slightly more than  $27^\circ$ , leaving about  $17\frac{1}{2}^\circ$  separation for the "counter-rotating" planes 1 and 7. They set an orbital elevation of 413 nautical miles to guarantee grazing angles to the subscriber units are always  $10^\circ$  or more. (Consideration of higher altitudes, e.g. 490 n.mi. which yields grazing angles of  $13^\circ$  minimum, are still under consideration.)

The engineers' choice of constellation primarily balanced the overall cost of the constellation with the system capacity (i.e. the number of subscriber units which can be provided service). In general, the capacity varies directly with the overall number of satellites -- a 6-by-8 constellation (six planes, eight satellites per plane) would offer about 62% the capacity of Iridium™'s 7-by-11 constellation, while an 8-by-12 constellation would offer about 25% more than the Iridium™ system. The cost of the constellation is driven by the number of satellites, together with the size and complexity of the satellites.

In addition to balancing the system's cost and the system's capacity, several other considerations led to the 7-by-11 constellation. The engineers did not want a constellation higher than 600 nautical miles because the radiation environment would drive up the hardware costs. The engineers did not want to go lower than 200 nautical miles because the station keeping, and fuel, requirements would become excessive due to the increased drag.

In order to change the current paradigm of mobile satellite telecommunications, which today is dominated by relatively-large, geostationary satellites, each currently costing hundreds of millions of dollars, it was decided that for the Iridium™ system to be viable in the commercial realm, it would truly need to offer a new paradigm for mobile communications. The worldwide internetting of portable, handheld subscriber units is very visible and noteworthy, but there is more. Motorola, a distinctively successful worldwide manufacturer of high quality wireless communications equipment, drew from its strength: high quality manufacturing. The heart of the Iridium™ system, a system on which a profitable commercial endeavor can be based, includes a warm production line of small satellites, in stark contrast to large, generally one-of-a-kind, satellites intended for a geostationary orbit. Yes, space systems are different, but not so different that time-proven manufacturing principles cannot be applied to both reduce costs and to increase quality simultaneously. Motorola will achieve this in conjunction with an experienced satellite manufacturer -- Lockheed. They were selected from several manufacturers from around the world who competed for this long-term production line.

The essence of a small, relatively simple, high quality design led to the decision to constrain the size, weight, and power limits to that of a Pegasus-like launch vehicle. Though a Pegasus, or a Pegasus-like launch vehicle has not been chosen for Iridium™ launches, and though an Ariane, Delta, Proton, Long March, or similar vehicles can be used to launch several Iridium™ space vehicles

RJL7-26-90LBGGCCNPRESENTED/PUBLISHED MOBILE SAT COMM CONF, ADELAIDE, AUSTRALIA, AUG 23, 1990

simultaneously, and though on-orbit sparing is a possibility, a Pegasus-like launch vehicle for the scheduled, as well as the unscheduled replacement of satellites, offers some advantages worth highlighting:

- 1) A "warm" well-exercised launch capability could lead to a more reliable and a less expensive capability, even if a dedicated aircraft were required;
- 2) Unscheduled replacement launches can be quickly scheduled, without today's concern for the availability of a polar-orbit launch site; and,
- 3) The Pegasus-like form-fit helps to enforce design, as well as cost, discipline into Iridium™ developmental process.

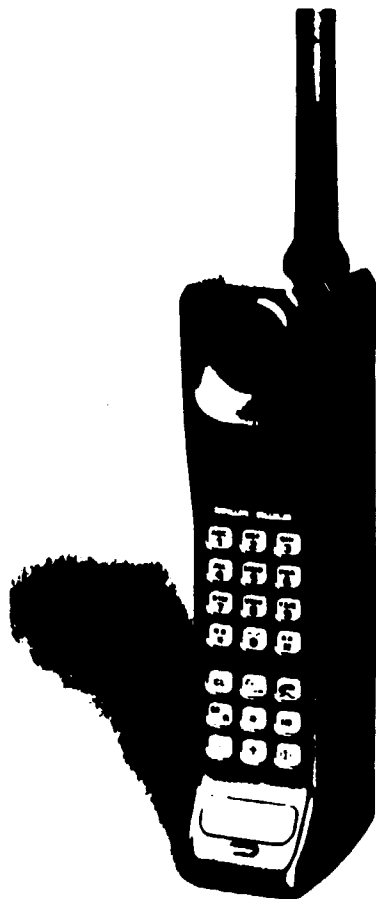
One further point needs to be made regarding the satellites. To maintain the satellites' cost control, the design philosophy has always focused on simplicity over complexity -- this implies avoiding deployment of anything on the satellites other than the solar arrays. The satellites' antenna systems went through several iterations and some of the candidates included deployables. Without deploying the antennas, the dimensions are quite restrictive. The baseline design includes multiple-beam, fixed phased arrays (refer to the photograph of the model) that do not need to be deployed. Alternative non-deployable designs are continuing to be evaluated, but the implications are clear: the \$25 million per satellite (on orbit) goal in a quantity of 77 is realistic, and the low-cost design implies little flexibility in the subscriber unit to/from satellite spectrum requirement (the system must be designed for a small piece of spectrum between 1 GHz and 3GHz).

## The Communication Network

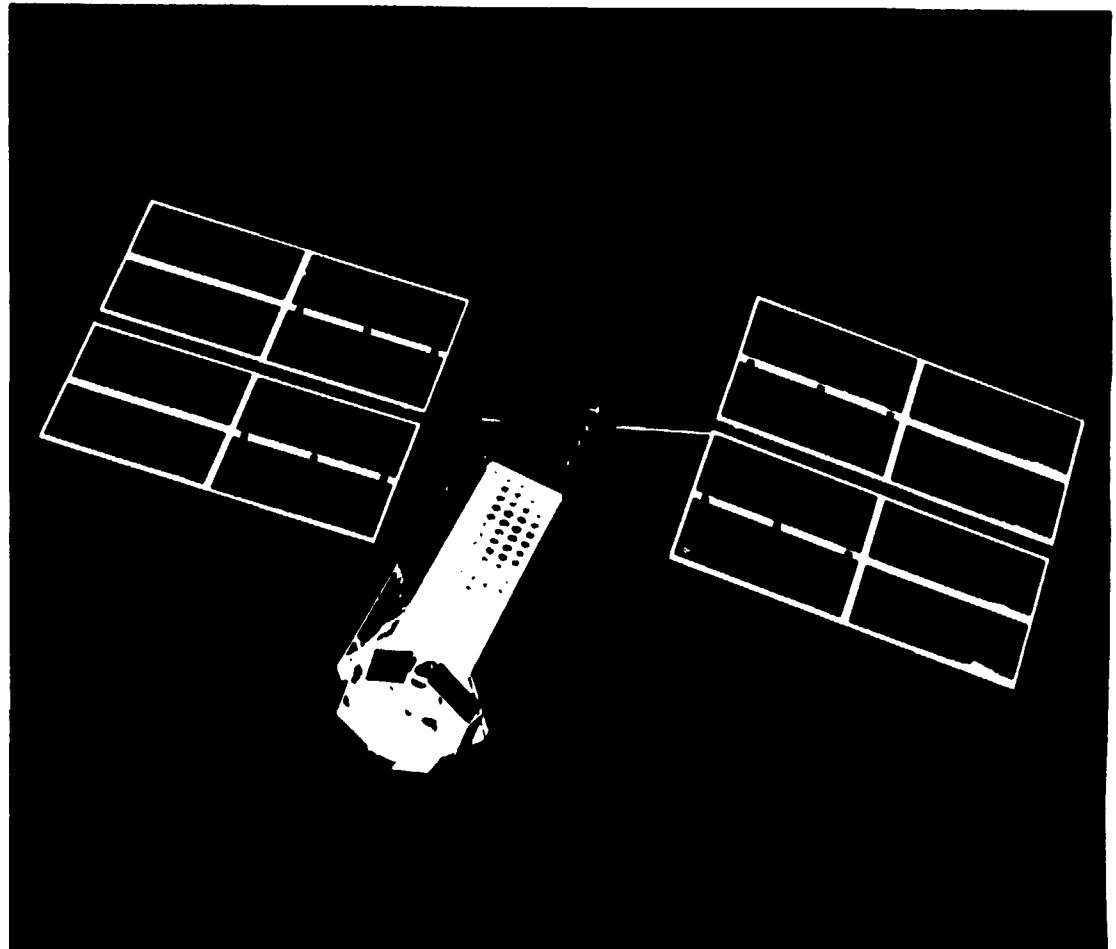
The Iridium™ system employs communication links in two portions of the spectrum. The up/down links between the satellites and the subscriber units are designed for L-Band operations. The satellites' crosslinks, as well as the up/down links to the gateways, are designed for Ka-Band operations. All links are circularly polarized.

The L-Band links are dictated by the available technology that can provide link closure between the small satellites and the portable user units. The L-Band network employs a 37-hexagonal cell pattern from each satellite. The cells are designed for independent operation and each employs a different amount of power to close the links. The cell pattern is fixed relative to the space vehicle, but rapidly moving on the earth's surface. Handoffs occur from cell to cell as a subscriber unit is operated, similar to today's cellular telephones, but unlike those cellular telephones, the Iridium™ cells move through the users, rather than the users moving through the cells. Handoffs occur with the same frequency, about one per minute, as cellular telephones, but involve fewer Iridium™ handoff options and better information to choose from among the options than today's cellular telephone systems. In that sense the Iridium™ system is less complex. However, since Iridium™ cell patterns overlap little in the low latitudes and very much in the high latitudes, the Iridium™ system has two problems to deal with that cellular telephones do not have:

- 1) Cells must be turned on/off depending upon their position in the orbit (when at the equator an individual cell will be on, and at some high latitude in each orbit it will be turned off for a period of time -- at any one time approximately 1,600 (56%) of 2,849 cells are on). Of course, if operation were prohibited in some part of the world, more would be turned off.
- 2) The channel reuse pattern must be reset at different times during an orbital period -- a modified 7-cell reuse pattern is used.



**Lightweight, portable subscriber units for the Iridium system communicate directly with satellites, using a small antenna.**



**Motorola's Iridium system is based on a constellation of 77 satellites in low earth orbit that use cellular technology to communicate with users on earth.**

The 7-cell reuse pattern was selected in a tradeoff analysis that considered the mainlobe and sidelobe interferences realized in alternative antenna designs. A theoretically more-efficient 6-cell pattern is possible, but not within the antenna design constraints. The 7-cell reuse pattern basically provides a buffer of two cells between any two cells using the same channel. Within any individual satellite, this separation is strictly maintained; between two adjacent satellites more than one, but less than two, buffer cells are maintained for the cells at the boundary line. This reuse pattern offers part of the spectral efficiency realized with the Iridium™ system -- worldwide, the same channel can be reused over 200 times. The modulation form is QPSK and the L-Band multiplexing scheme is a combination of TDMA and FDMA. Over an area the size of the United States' 48 contiguous states, forty cells are formed with an average of 2 KHz of spectrum needed per usable channel. The reuse assignments employ a combination of fixed and dynamically assigned channels, so that both the entire world as a whole, as well as the possibly higher concentration of users in isolated localities, can be handled with a balanced efficiency. For the current baseline point design for the initial constellation, the typical 360 n.mi. diameter cell can service up to approximately 150 simultaneous users, while isolated individual cells can handle 2 to 3 times that many.

Since no one can truly estimate the number of subscribers the Iridium™ system will generate or the usage patterns of those subscribers, it is difficult to put an exact number on the subscriber units the system can accommodate -- nevertheless by most accounts, the 2% average user rate experienced by cellular telephones is thought to be high; but, even if the Iridium™ system were used at this 2% rate with the baselined point design, several million users in reasonable locations in the temperate latitudes can be serviced (virtually all the others, in less likely subscriber areas, can also be serviced).

The Iridium™ system would break even financially with the baseline design at about 500,000 users worldwide, while 870,000 users represents a very lucrative business. The baseline architecture does allow for growth, and of course the initial constellation's capacity could be adjusted slightly higher or lower to accommodate costs, spectrum allocations, schedule adjustments or other non-technical considerations.

The Ka-Band network employs up to four crosslinks per satellite and up to four independent gateways per satellite. The crosslink and gateway architecture is designed for growth and each link is initially baselined at 3,000 user channels. The System Control Facilities will also use this network, employing 128 channels. Two control facilities, each located at relatively high latitudes, are included in the baseline point design. Though nominal locations for these facilities, as well as that for the minimum of 20 gateways (earth stations) are carried in the point design, for the initial system, the final locations will be determined by the consortium which will operate the system. In a mature system that has grown over time, hundreds of gateways are possible.

The gateways employ a minimum of two 3.3 meter tracking dish antennas that are separated by up to 20 miles -- in areas of reasonably frequent thunderstorm activity a third, and perhaps a fourth, geometrically-separated antenna will be employed. The antenna separation also assures that no sun orientation will incapacitate the gateway linkage from the constellation.

The gateways also include the interface electronics to reconfigure the Iridium™ system's 4.8 KBPS voice capability to the Postal, Telephone and Telegraph Authorities (PTTs) through the world's public switched telephone networks (PSTNs). (The gateway includes the local switch.) Though some people question the quality of 4.8 KBPS vocoders, it is important to recognize that the capacity and the spectral efficiency is directly related to the vocoder selected, and since all the vocoders are ground-based (the satellites are nothing more than transmitters, receivers, and digital switches, i.e. baseband processors), the system is baselined at what is practical for the mid-1990's -- some "critics" have actually advocated the more efficient 2.4 KBPS vocoder. The Iridium™ system does include "version numbers" in its protocol, so as time goes on, if a high-quality 2.4 KBPS vocoder is available, future satellites can handle both versions.

Though a variety of voice and/or data subscriber units are feasible, the initial development focuses on the individual portable/handheld unit, the mobile unit which can be installed in an automobile or boat, and the transportable unit that can be moved between remote fixed locations.

The mobile and transportable units anticipate the availability of power sources and antenna orientations better suited to wireless communications than the portable/handheld unit.

The portable/handheld unit can operate for 24 hours on a single recharge -- 23 hours of standby (able to receive a "ring" indicating an incoming call) plus 1 hour of operation. The antenna "stub" can provide -1dB or more gain. The biological RF safety margin of approximately 1 watt can be maintained -- the system can be operated with 600 mW user units (comparable to cellular telephones). The subscriber unit has an optional Global Positioning System (GPS) capability which can enhance the unit's timing, positioning, and warm-up capabilities, but the Iridium™ system is not dependent upon GPS for operation. Without GPS a user unit starting from a "cold start" from a new location anywhere in the world can become functional within the Iridium™ system in less than 1 minute. The small functional design of the subscriber unit is possible due to the efficient distribution of functionality among user units, satellites, gateways, and the system control facilities. And, though the hardware is minimized, the subscriber unit is capable additionally of monitoring signals in channels other than its own assigned channel to assist in the execution of handoff operations.

## Summary

A low-earth global cellular communication was described as were many of the key system-level considerations which have driven the design. Many specific details were omitted, both because of the limitations imposed by this forum and because of the competitive nature of the mobile telecommunications business.

The Iridium™ Mobile Satellite Communications System represents a bold step into the future in terms of portable radiotelephone capability and its worldwide networking capability. Not to be slighted is the pioneer effort in manufacturing that is embodied in a warm commercial production line of satellites supporting a dynamic constellation frequently maintained with new satellite launches and old satellite decommissionings.

The Iridium™ team is a team of professionals, well educated and each with considerable experience. They have no illusions concerning what has been done, what is yet to be done, and what alliances are essential for success. They are highly motivated and eager to join with others from around the globe to bring the Iridium™ system into reality on cost, on schedule, and within specification.

The technical know-how for a revolutionary global mobile telecommunications system is at hand; what remains is the collective will to surpass the regulatory and licensing barriers. The door is open for both technical and non-technical local noble content. The rest of the story remains to be written.

- (1) Adams, W.S. and L. Rider, "Circular Polar Constellations Providing Continuous Single or Multiple Coverage Above a Specified Latitude," The Journal of the Astronautical Sciences, Vol. 35, No. 2, Apr-Jun 1987.



**Attachment C**

**MULTIPLE BEAM DEPLOYABLE SPACE ANTENNA SYSTEM**

**U.S. PATENT NO. 5,017,925**

**(MAY 21, 1991)**

**United States Patent** [19]

Bertiger et al.

[11] Patent Number: **5,017,925**[45] Date of Patent: **May 21, 1991**[54] **MULTIPLE BEAM DEPLOYABLE SPACE ANTENNA SYSTEM**[75] Inventors: **Bary R. Bertiger, Scottsdale;**  
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**Ariz.**[73] Assignee: **Motorola, Inc., Schaumburg, Ill.**[21] Appl. No.: **596,623**[22] Filed: **Oct. 10, 1990****Related U.S. Application Data**

[63] Continuation of Ser. No. 415,814, Oct. 2, 1989, abandoned.

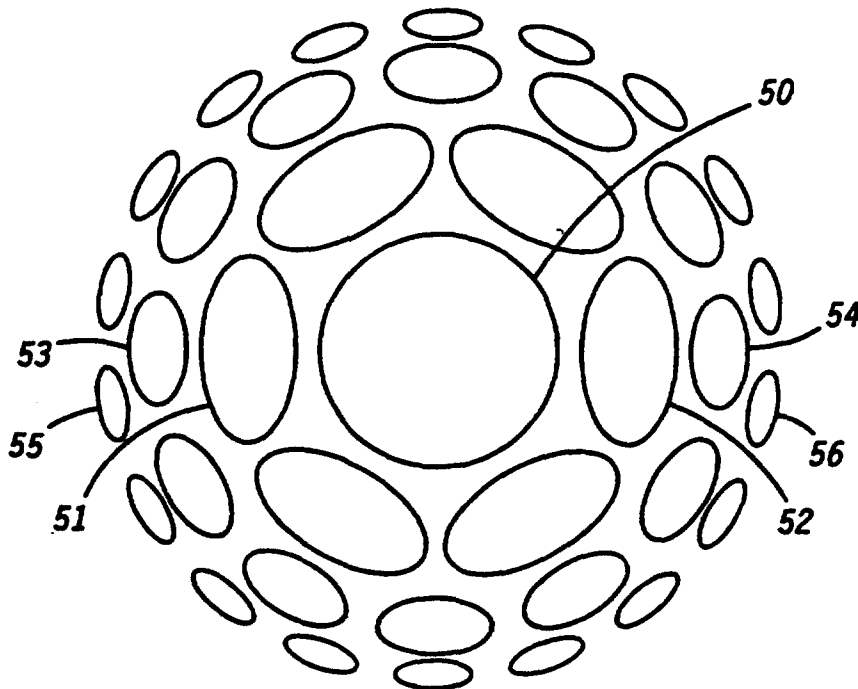
[51] Int. Cl.<sup>3</sup> ..... **H04B 7/185**[52] U.S. Cl. .... **342/352; 343/DIG. 2;**  
**342/353**[58] Field of Search ..... **342/352, 353, 356;**  
**343/DIG. 2, 898, 705, 708, 776**[56] **References Cited****U.S. PATENT DOCUMENTS**

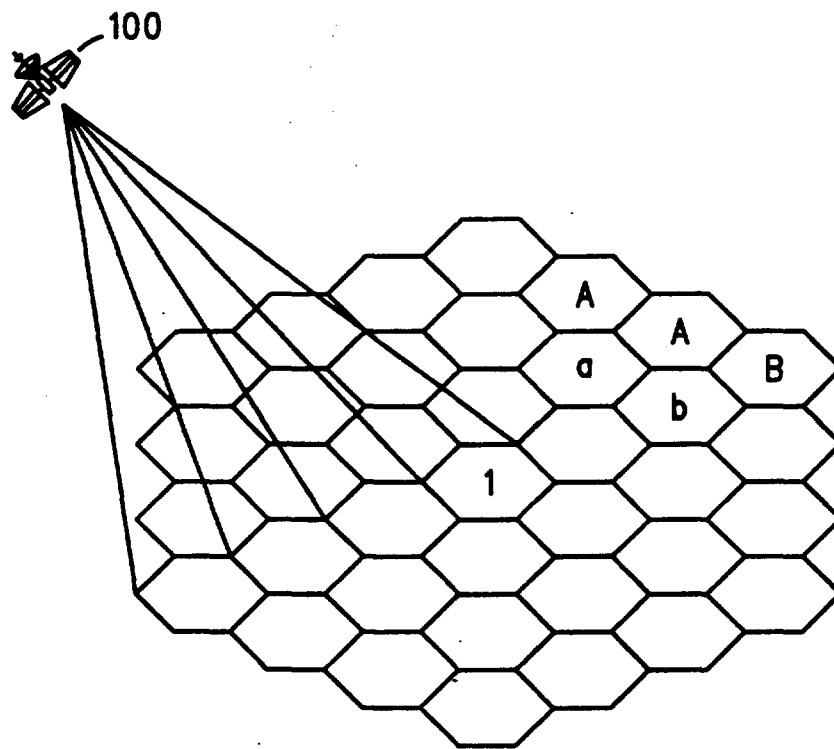
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*Primary Examiner*—Theodore M. Blum*Attorney, Agent, or Firm*—Frank J. Bogacz[57] **ABSTRACT**

A multiple beam space antenna system for facilitating communications between a satellite switch and a plurality of earth-based stations is shown. The antenna is deployed after the satellite is in orbit by inflation of a raft-type supporting structure which contains a number of antenna horns. These antenna horns are oriented in substantially concentric circular groups about a centrally located antenna horn. Each of the antenna beams projects an area on the earth. Each of the areas of the beams are contiguous. As a result, one large area is subdivided into many smaller areas to facilitate communications. In addition, a lens may be employed to focus the beams of the horn antennas.

**25 Claims, 5 Drawing Sheets**



**FIG. 1**

**FIG. 2**

